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Spark-Induced Breakdown Spectroscopy (SIBS) Monitor for Metals in Soil

DESCRIPTION OF THE TECHNOLOGY

With support from the Environmental Protection Agency's (EPA) Small Business Innovation Research (SBIR) Program, Physical Sciences Inc. (PSI), has developed a prototype monitor for the onsite characterization of soil using spark-induced breakdown spectroscopy (SIBS). This device determines the elemental composition of soil by emission spectroscopy, including dangerous heavy metal pollutants, using an electrically generated pulsed plasma as an excitation source.

The PSI prototype metals monitor is based on the excitation of a sample with a large, robust electric spark. Following the excitation, the elements in the sample emit light. These emissions provide the basis for the detection: the energy of the radiated light identifies the element and the intensity of the light indicates the concentration of the element in the matrix. The use of a small spectrometer enables simultaneous multi-metal determinations. Analytical methodology is based on the use of standard additions to the sample and normalization to persistent iron lines. Detection limits for lead (Pb), chromium (Cr), cadmium (Cd), mercury (Hg), and barium (Ba) have been determined to be near 25 mg metal/kg

soil, and determination times of a few minutes are possible.

SIGNIFICANCE OF THE TECHNOLOGY

Metals are a ubiquitous waste material present in soils and sediments at sites across the United States. Contamination levels range from individual species present at low concentrations to multiple class mixtures present in parts per thousand quantities. These sites are the result of years of disposal of chemicals into the environment. Prior to the 1970s, disposal of hazardous material into unlined shallow pits was a common practice. This method minimized costs associated with waste disposal, and the general public was mostly ignorant of the dangers caused by the disposed chemicals. Moreover, it was generally assumed, even more recently, that metals buried in soils remained in the top few centimeters of soil. This is now known not to be the case. Hazardous wastes spilled or disposed on land migrate through the surface and subsurface soils under certain conditions, and can access groundwater and aquifers.

When hazardous waste sites are under remediation, samples of soil are continuously collected and analyzed.

SBIR Impact

- ✦ SIBS determines the elemental composition of soil by emission spectroscopy using electrically generated pulsed plasma as an excitation source.
- ✦ Using the technology, detection limits for Pb, Cr, Cd, Hg, and Ba have been determined to be near 25 mg metal/kg soil, and determination times of a few minutes are possible.
- ✦ SIBS offers greater potential sensitivity and more representative sampling than other technologies, such as laser-induced breakdown spectroscopy.
- ✦ By operating *in situ*, the technology avoids the high capital and operating costs of inductively coupled plasma atomic emission spectroscopy and microwave methods.



PSI's SIBS monitor determines the elemental composition of soil, including dangerous heavy metal pollutants.

These samples determine the type and extent of the contamination, and ongoing sampling is necessary as the remediation proceeds. These samples are usually analyzed offsite in a laboratory setting. This approach is reliable, but the time required for the continuing sample/analysis iteration is lengthy and adds substantially to the labor budget of site clean up. A portable or onsite multi-metals field-screening instrument will be a valuable addition to the onsite arsenal of the hazardous waste remediation team.

SIBS offers greater potential sensitivity and more representative sampling than other technologies, such as laser-induced breakdown spectroscopy, and uses an inexpensive spark power supply in place of a laser. By operating *in situ*, the technology avoids the high capital and operating costs of inductively coupled plasma atomic emission

spectroscopy and microwave methods and uses simple and inexpensive radiometric optical detection.

SIBS was evaluated at a joint EPA/U.S. Department of Energy test at the Rotary Kiln Incinerator Facility at Research Triangle Park, NC. The instrument was configured for real-time, *in situ* measurement of Pb and Cr in gas-borne particulate at target levels of 15 and 75 $\mu\text{g}/\text{dscm}$ in simulated combustion flue gas. Both Pb and Cr were detected at the low- and high-level concentrations. The hardware performed without failure for more than 100 hours of operation and acquired data for all of the reference tests (data were acquired using EPA Reference Method 29).

COMMERCIALIZATION SUCCESS

Although not yet fully commercialized, this monitor has attracted a good deal of attention from potential commercial partners. Using internal funding, PSI has designed a manufacturable model of the monitor that will be the size of a briefcase and be saleable on the open market for less than \$10,000.

COMPANY HISTORY

PSI was founded in 1973 by employees of Avco-Everett, a large and well-known defense contractor. Since then, PSI has focused on providing contract research and development services in a variety of technical areas to both government and commercial customers. PSI has a staff of more than 120, approximately one-half of whom are at the doctoral level. The company's core technologies have been developed with more than \$250 million of federal and industrial funding over 3 decades of operations, a period in which PSI has acquired an international reputation for technical excellence and innovation. The SBIR Program has played a pivotal role in PSI's technical and commercial success, and has been responsible for a family of intelligent instrumentation products based on proprietary electro-optical and electromechanical technologies.

What is the SBIR Program?

EPA's Small Business Innovation Research (SBIR) Program was created to assist small businesses in transforming innovative ideas into commercial products. The SBIR Program has two phases—Phase I is the feasibility study to determine the validity of the proposed concept and Phase II is the development of the technology or product proven feasible in Phase I. EPA also offers Phase II Options to accelerate the commercialization of SBIR technologies and to complete EPA's Environmental Technology Verification (ETV) Program. For more information about EPA's SBIR Program and the National Center for Environmental Research, visit <http://www.epa.gov/ncer/sbir>.